Instructor(s):
Instructor: Dr. Tom Blasingame (Section 501)
Office: RICH 815
Lecture: MWF 13:50-14:40 a.m. RICH 302
Office Hours: by appointment — or if my office is open, I am available.
Phone: (979) 845-2292
e-mail: t-blasingame@tamu.edu

Texts: (Available at MSC Bookstore, can also be ordered directly from SPE (probably at reduced rates), you must be an SPE member — SPE (800) 456-6863)

Reference Materials:
1. Course materials for this semester are located at:
   
   http://pe.tamu.edu/~t-blasingame/P613_05A/

2. An extensive compilation of reference notes, old text materials, etc. are located at:
   
   http://pe.tamu.edu/~t-blasingame/P613_reference/

   Note: The most materials are in .pdf files and some of these files are quite large — you should not open these files on the server, but rather, you should DOWNLOAD the .pdf to your local computer.

3. Journal articles (to be made available in electronic formats)
4. Other text materials:

Basis for Grade:

Homework/Projects ........................................................................................................................................................................90%
Class Participation ........................................................................................................................................................................  10%

Total = 100%

Grade Cutoffs: (Percentages)
A: < 90    B: 89.99 to 80    C: 79.99 to 70    D: 69.99 to 60   F: < 59.99

Policies and Procedures:

1. Students are expected to attend class every session.
2. Policy on Grading
   a. It shall be the general policy for this course that homework, quizzes, and exams shall be graded on the basis of answers only — partial credit, if given, is given solely at the discretion of the instructor.
   b. All work requiring calculations shall be properly and completely documented for credit.
   c. All grading shall be done by the instructor, or under his direction and supervision, and the decision of the instructor is final.
3. Policy on Regrading
   a. Only in very rare cases will exams be considered for regrading; e.g., when the total number of points deducted is not consistent with the assigned grade. Partial credit (if any) is not subject to appeal.
   b. Work which, while possibly correct, but cannot be followed, will be considered incorrect — and will not be considered for a grade change.
   c. Grades assigned to homework problems will not be considered for regrading.
   d. If regrading is necessary, the student is to submit a letter to the instructor explaining the situation that requires consideration for regrading, the material to be regraded must be attached to this letter. The letter and attached material must be received within one week from the date returned by the instructor.
4. The grade for a late assignment is zero. Homework will be considered late if it is not turned in at the start of class on the due date. If a student comes to class after homework has been turned in and after class has begun, the student's homework will be considered late and given a grade of zero. Late or not, all assignments must be turned in. A course grade of Incomplete will be given if any assignment is missing, and this grade will be changed only after all required work has been submitted.
5. Each student should review the University Regulations concerning attendance, grades, and scholastic dishonesty. In particular, anyone caught cheating on an examination or collaborating on an assignment where collaboration is not specifically allowed will be removed from the class roster and given an F (failure grade) in the course.
Course Description

*Graduate Catalog*: Flow of natural gas in reservoirs and in wellbores and gathering systems; deliverability testing; production forecasting and decline curves; flow measurement and compressor sizing.

*Translation*: From the reservoir through the sales line—we will try to study every aspect of natural gas systems. PVT properties, flow in porous media, flow in pipes and thermodynamic properties will be studied. We will use the Lee and Wattenbarger and the ERCB texts as guides—as well as numerous technical papers that go into much more depth of detail for a particular problem. We will focus on well testing, deliverability analysis, and decline curve analysis, as well as wellbore flow phenomena.

**Prerequisites by Topic**: Differential and integral calculus, Ordinary and partial differential equations, Thermodynamics, Fluid dynamics and heat transfer, Reservoir fluid properties, and Reservoir petrophysics.

Course Objectives

The student should be able to:

- Estimate oil, gas, and water properties pertinent for well test or production data analysis using industry accepted correlations and laboratory data.
- Sketch pressure versus time trends and pressure versus distance trends for a reservoir system exhibiting transient, pseudosteady-state, and steady-state flow behavior.
- Derive the steady-state and pseudosteady-state relations for gas flow (including rigorous and semi-analytical relations for boundary-dominated flow behavior). In addition, the student must be able to derive, in complete detail, the pressure, pressure-squared, and pseudopressure forms of the diffusivity equation for a real gas.
- Derive the material balance equations for a volumetric dry gas reservoir, an "abnormally-pressured" gas reservoir, and a water-drive gas reservoir. The student should also be familiar with the generalized (i.e., compositional form) of the material balance equation for a gas condensate reservoir.
- Derive and apply the conventional relations used to calculate the static and flowing bottomhole pressures for the case of a dry gas. The student should also be familiar with proposed techniques for wet gases.
- Derive/present models for wellbore storage and phase redistribution (gas systems).
- Derive the "skin factor" variable from the steady-state flow equation and be able to describe the conditions of damage and stimulation using this skin factor. The student should also be familiar with models for “variable” skin effects due to non-Darcy flow, well cleanup, and gas condensate banking (radial composite model).
- Analyze and interpret flow-after-flow (4-point) and isochronal flow tests.
- Derive the analysis and interpretation methodologies (i.e., “conventional” plots and type curve analy-sis) for pressure drawdown and pressure buildup tests (liquid or gas reservoir systems). Also, be able to apply dimensionless solutions (“type curves”) and field variable solutions (“specialized plots”) for the analysis and interpretation of well test data.
- Design and implement a well test sequence, as well as a long-term production/injection surveillance program. This includes the design of single and multipoint deliverability tests.
- Analyze production data (rate-time or pressure-rate-time data) to obtain reservoir volume and estimates of reservoir properties for gas and liquid reservoir systems. The student should be able to use "decline curves," "decline type curves," and other techniques of analysis for production data.
- The student should be familiar with the reservoir engineering tools used to analyze/interpret the performance of the following gas reservoir types:
  - Gas condensate reservoir systems
  - Low permeability/unconventional reservoirs
  - Low pressure gas reservoirs
<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module 1</strong> Introductory Concepts</td>
<td></td>
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<tr>
<td>January</td>
<td>University Holiday</td>
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<tr>
<td>17 M</td>
<td>Course Introduction/Review of Syllabus</td>
<td>(Syllabus — Spring 2005)</td>
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<tr>
<td>19 W</td>
<td>Introduction: historical perspectives, types of tests, etc.</td>
<td>ERCB Ch. 1, Katz Ch 1-2,9</td>
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<tr>
<td>21 F</td>
<td>Reservoir performance behavior (introduction)</td>
<td>ERCB Ch. 2, LW Ch. 5</td>
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<tr>
<td>24 M</td>
<td>Properties of reservoir fluids</td>
<td>ERCB App. A, LW Ch. 1, Katz Ch 3-5,12, Hnd</td>
</tr>
<tr>
<td>26 W</td>
<td>Properties of reservoir fluids</td>
<td>ERCB App. A, LW Ch. 1, Katz Ch 3-5,12, Hnd</td>
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<tr>
<td><strong>Module 2</strong> Gas Material Balance and Boundary Dominated Flow Behavior</td>
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<tr>
<td>February</td>
<td>Fundamentals of fluid flow in porous media (general)</td>
<td>ERCB Ch. 2, LW Ch. 5, Katz Ch 2, Hnd</td>
</tr>
<tr>
<td>02 W</td>
<td>Fundamentals of fluid flow in porous media (gas)</td>
<td>ERCB Ch. 2, LW Ch. 5, Katz Ch 2, Hnd</td>
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<tr>
<td>04 F</td>
<td>Gas material balance (simple case)</td>
<td>LW Ch. 10, Katz Ch 12, Hnd</td>
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<tr>
<td>07 M</td>
<td>Gas material balance (&quot;abnormal&quot; pressure case)</td>
<td>LW Ch. 10, Hnd</td>
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<tr>
<td>09 W</td>
<td>Gas material balance (water influx case)</td>
<td>LW Ch. 10, Hnd</td>
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<tr>
<td>11 F</td>
<td>IPR concepts for gas wells</td>
<td>ERCB Ch. 3, LW Ch. 4, Hnd</td>
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<tr>
<td>14 M</td>
<td>Semi-analytical performance equation ($\phi(t)$ vs. $t$) for gas wells</td>
<td>Hnd</td>
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<tr>
<td><strong>Module 3</strong> Wellbore Phenomena and Near-Well Reservoir Behavior</td>
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<tr>
<td>March</td>
<td>Deliverability testing of gas wells (Introduction)</td>
<td>Hnd (Rawlins/Schellhardt), Katz Ch 9,11</td>
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<tr>
<td>02 W</td>
<td>Deliverability testing of gas wells</td>
<td>ERCB Ch. 3, LW Ch. 7, Katz Ch 9,11, Hnd</td>
</tr>
<tr>
<td>04 F</td>
<td>Well test analysis: Fundamentals (solutions, plots, simple analysis, etc.)</td>
<td>ERCB Ch. 4-5, LW Ch. 6, Katz Ch 10</td>
</tr>
<tr>
<td>07 M</td>
<td>Well test analysis: Fundamentals (solutions, plots, simple analysis, etc.)</td>
<td>ERCB Ch. 4-5, LW Ch. 6, Katz Ch 10</td>
</tr>
<tr>
<td>09 W</td>
<td>Well test analysis: Model-based analysis (Unfractured wells)</td>
<td>ERCB Ch. 7, LW Ch. 6, Hnd</td>
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<tr>
<td>11 F</td>
<td>Well test analysis: Model-based analysis (Fractured Wells)</td>
<td>ERCB Ch. 7, LW Ch. 6, Hnd</td>
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<td>Spring Break: 14-18 March 2005</td>
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<tr>
<td><strong>Module 4</strong> Well Test Analysis</td>
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<tr>
<td>March</td>
<td>Well test analysis: Model-based analysis (etc.)</td>
<td>ERCB Ch. 7, LW Ch. 6, Hnd</td>
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<tr>
<td>02 W</td>
<td>Well test analysis: Well test design</td>
<td>ERCB Ch. 4-5, LW Ch. 8, Hnd</td>
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<tr>
<td>04 F</td>
<td>Reading Day (No Classes — Good Friday)</td>
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<tr>
<td><strong>Module 5</strong> Analysis and Modelling of Production Data</td>
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<tr>
<td>April</td>
<td>Analysis of production data: Data acquisition, cataloging, and retrieval</td>
<td>LW Ch. 9, Hnd</td>
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<tr>
<td>01 F</td>
<td>Analysis of production data: Conventional decline curve analysis</td>
<td>LW Ch. 9, Hnd</td>
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<tr>
<td>04 M</td>
<td>Analysis of production data: EUR analysis</td>
<td>Hnd</td>
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<tr>
<td>06 W</td>
<td>Analysis of production data: Model-based analysis</td>
<td>LW Ch. 9, Hnd</td>
</tr>
<tr>
<td>08 F</td>
<td>Analysis of production data: Model-based analysis</td>
<td>LW Ch. 9, Hnd</td>
</tr>
<tr>
<td><strong>Module 6</strong> Special Topics in Gas Reservoir Engineering</td>
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<tr>
<td>11 M</td>
<td>Performance of gas condensate reservoir systems</td>
<td>Katz Ch 12, Hnd</td>
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<tr>
<td>13 W</td>
<td>Low permeability/ unconventional gas reservoirs (characterization)</td>
<td>Hnd</td>
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<tr>
<td>15 F</td>
<td>Low pressure gas reservoir systems</td>
<td>Hnd</td>
</tr>
<tr>
<td>18 M</td>
<td>Underground storage of natural gas</td>
<td>Katz Ch 18, Hnd</td>
</tr>
<tr>
<td>20 W</td>
<td>Underground storage of natural gas</td>
<td>Katz Ch 18, Hnd</td>
</tr>
<tr>
<td>22 F</td>
<td>Special topics (analysis of well performance data from low permeability gas reservoirs)</td>
<td>Hnd</td>
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<tr>
<td>25 M</td>
<td>Special topics (analysis of well performance data from low permeability gas reservoirs)</td>
<td>Hnd</td>
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<tr>
<td>27 W</td>
<td>Special topics (analysis of well performance data from low permeability gas reservoirs)</td>
<td>Hnd</td>
</tr>
<tr>
<td>29 F</td>
<td>Special topics (TBA)</td>
<td>Hnd</td>
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<tr>
<td>May</td>
<td>(dead day) Software for the analysis of well test data</td>
<td>Hnd</td>
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<tr>
<td>02 M</td>
<td>(redefined day (&quot;Friday&quot;)) Software for the analysis of production data</td>
<td>Hnd</td>
</tr>
<tr>
<td>03 T</td>
<td>Final Exam/Project - RICH 302 from 03:30 - 05:30 p.m. (MWF 01:40 - 02:50 p.m.)</td>
<td>Hnd</td>
</tr>
</tbody>
</table>

Petroleum Engineering 613 — Natural Gas Engineering
Course Description, Prerequisites by Topic, and Course Objectives
Spring 2005 (Spring Break: 14-18 March 2005)
Homework Topics: (These are intended topics, addition and/or deletion of certain problems may occur as other problems become available. Multiple assignments from each topic are possible.)

- Reservoir fluids — analysis/prediction of phase behavior.
- Gas material balance.
  - Normally-pressured dry gas reservoirs.
  - Abnormally-pressured dry gas reservoirs.
  - Water Influx/Encroachment.
  - Gas condensate reservoirs.
- Wellbore storage/phase redistribution models (gas).
- Skin factor/impediments to flow.
- Deliverability testing (single point, multipoint, and isochronal tests).
- Analysis and interpretation of gas well test data.
- Well test design.
- Analysis and interpretation of gas well production data.
- Special topics.
  - Gas condensate reservoir systems (PTA/P4).
  - Low permeability/unconventional reservoirs.
  - Low pressure gas reservoirs.

Computing Topics: In general, some programming (spreadsheet/Visual Basic) assignments may be required. Students must develop their own codes unless otherwise instructed.

Homework Format Guidelines:
I. General Instructions: You must use engineering analysis paper or lined notebook paper, and this paper must measure 8.5 inches in width by 11 inches in height

1. You must only write on the front of the page.
2. Number all pages in the upper right-hand corner and staple all pages together in upper left hand corner. You must also put your name (or initials) in the upper right corner of each page next to the page number (e.g. John David Doe (JDD) page 4/6).
3. Fold inward lengthwise.
4. Place the following identification on the outside:
   - Name: (printed)
   - Course: Petroleum Engineering 324/Spring 2005
   - Date: 25 January 2003
   - Assignment: (Specific)

II. Homework Format
1. Given: (Statement of Problem and Problem Data)
2. Required: (Problem Objectives)
3. Solution: (Methodology)
   A. Sketches and Diagrams
   B. Assumption, Working Hypotheses, References
   C. Formulas and Definitions of Symbols (Including Units)
   D. Calculations (Including Units)
4. Results
5. Conclusions: Provide a short summary that discusses the problem results.

Instructor Responsibilities
The instructor is responsible for
1. A learning environment where students of all skills levels are appropriately challenged.
2. Showing respect and consideration to the students.
3. Being prepared for class and keeping on schedule with the syllabus.
4. Preparing exercises that follow the course objectives.
5. Covering the material that will be tested on exams.

The instructor is not responsible for
1. Work missed by absent students (unless a University-excused absence is provided to the instructor).
2. Poor performance by unattentive or uninterested students. This is a fundamental course in Reservoir Engineering, one that you will use actively in your career as a reservoir or production engineer.
3. Personal issues — if you have personal issues that impair your performance in this course, you are encouraged to discuss these problems with your instructor for possible remedies. However, the instructor is responsible for assigning your grade based solely on your performance and is not at liberty to allow personal appeals to influence your grade.

Student Responsibilities
The student is responsible for
1. Class attendance. Students should attend all scheduled class meetings.
2. Being prepared for class. In-class quizzes will be given. Always bring your books, course notes, and calculator to each class meeting.
3. Being prepared for exams. The instructor or TA may choose to review materials prior to exams, but do not rely on this review as your only exam preparation—nor should you rely on old exams for your exam preparation. The best preparation for exams is to stay current with the class, rework assignments, and get plenty of rest the night before the exam.
4. Showing respect and consideration to his classmates and the instructor. Do not talk excessively with your neighbors during class. Do not take up class time for discussions with the instructor that should be held outside of class. Students who disrupt the class will be asked to leave.